**Heated Cylinder**

This invention relates to a heated cylinder for heating a paper web, cardboard web, tissue web or other fiber web in a machine used for producing and/or refining the fiber web, said heated cylinder comprising a cylinder sleeve which is impinged upon at least in part from the inside by a hot fluid and has at least one inner and an outer sleeve layer.

Such a heated cylinder is known from DE 102 60 509.2. On the known cylinder the tensile stresses which arise because the inner region of the cylinder expands more intensively than the outer region are minimized by the cylinder sleeve being comprised of at least two sleeve layers and by the material of the outer sleeve layer having, compared to the material of the inner sleeve layer, a larger coefficient of thermal expansion at a mounted temperature below the mean operating temperature and a smaller coefficient of thermal expansion at a mounted temperature above the mean operating temperature. A further measure consists of the layer thickness of the outer sleeve layer being smaller than that of the inner sleeve layer.

On drying cylinders of this type a temperature gradient forms in the direction of the surface during the paper drying process. The surface temperature of the cylinder is lower than the temperature of the steam with which the cylinder is heated, and this means that the drying capacity is limited. Usually it makes no sense for economic reasons to increase the temperature of the saturated steam.

From EP 0 559 628 B1 there is known a dryer for drying a fiber web, on which a through-flow cylinder is used in conjunction with a hood blower. The latter is equipped with a nozzle arrangement with whose help jets of drying gas are directed on to the outer surface of the web to be dried while said web is being guided over a sector of approx. 270° or more around the heated cylinder. The sleeve of the cylinder is equipped with a system of duct pipes into which a coolant can be conveyed from a coolant source. Thanks to the jets of drying gas, water in the web is vaporized outwards and removed through spaces in the hood blower. On the other hand, water from the web condenses on the cooled sleeve surface of the cylinder and is drawn off by means of the perforation in the outer sleeve of the cylinder and a negative

pressure existing inside the cylinder . The entire interior space of the cylinder is available for accommodating the condensate. Hence the inner wall of the cylinder must have a certain minimum wall thickness in order to be able to withstand the compressive loads given the cylinder diameters used.

The object of the present invention is to increase the drying performance of a heatable cylinder.

This object is accomplished in accordance with the invention with a heatable cylinder of the type initially referred to in that the two sleeve layers are separated from each other by a hollow space into which the fluid can be introduced. As the result of the double-shell construction of the drying cylinder the temperature gradient between the cylinder surface and the steam is reduced and kept low.

Thanks to the invention the wall thickness of the outer sleeve layer can be kept small; in particular the loads of the outer wall of the cylinder can be kept small by supports resting against the core of the cylinder or by cross-struts. As the result of the small wall thickness of the outer sleeve layer of the cylinder enabled thereby, the temperature gradient in this sleeve layer can also be kept small. Given the reduction of thermal resistance compared to conventional cylinders it is possible to increase the drying performance of the cylinder achieved with the same steam pressure in that the heat flow through the outer sleeve layer is improved and the temperature on the outer cylinder surface is increased.

Unlike a conventional drying cylinder which is subjected to pressure throughout the interior space, the pressure in the double-shell solution of the invention acts only in the ring-shaped cross section between the outer shell and the outside of the inner shell, which are fixed relative to each other by means of connection elements. In this case the outer shell is held back by the connection elements as the result of the pressure acting in opposite direction on the inner shell, thus reducing the load on the inner shell likewise. The remaining load for both shells is defined by the pressure and the difference of the pressurized areas, which corresponds to the difference of their diameters.

The shells can be constructed far thinner thanks to the reduction of the load, enabling a reduction of dead weight for the same load capacity and an improvement of heat transfer due to the smaller wall thickness.

The inventive measure proves to be particularly advantageous in the case of a drying arrangement in which the cylinder, as known from EP 0 559 628 B1, is covered with a hood over a large overrolling region of its sleeve surface, for example 270°.

The hood is filled with a medium, in particular water, at a positive pressure of 1 to 5 bar. Owing to the fact that the hood is stationary and does not enclose the entire circumference, the sleeve surface is subjected to a cyclic load. Therefore, a compressive load acts on a point on the sleeve surface of the cylinders as soon as the point moves into the region which is enwrapped by the pressure hood. The pressure is relieved again as soon as the point leaves this region. The pressurization produces a high mechanical load that acts on the cylinder surface moreover cyclically with each rotation. Drying cylinders of conventional design would be unable to withstand such compressive loading.

Advantageous further aspects of the invention emerge from the subclaims, the description and the drawings.

In particular it is an advantage for the inner sleeve layer to be thicker than the outer sleeve layer.

The outer shell is preferably thin-walled in construction and has a wall thickness in the range between 5 and 15 mm, in particular between 8 and 15 mm. It is connected to the rigid core of the cylinder by means of bars. Between the thin outer shell and the core is the steam space.

Advantageously the steam in the hollow space between the two sleeve layers has a positive pressure of between 2 and 13 bar.

An advantageous measure entails applying a structure with ribs or platelets on to the inner surface of the outer sleeve layer facing the hollow space, with the structure

extending in axial direction. This contributes to the temperature gradient between the outer sleeve surface of the drying cylinder and the hollow space with the hot medium between the inner wall and the outer wall being kept small.

During operation the condensate collects at the bottom of the ribs. Even a small condensate film thickness would have a great thermally insulating effect and increase the temperature gradient toward the cylinder surface. By contrast, the flank region of the ribs is not covered with condensate and therefore stands in direct contact with the steam, thus catering for a high thermal flow. Similarly, the enlarged surface of the outer shell of the cylinder resulting from the ribs improves the heat transfer by increasing the area of contact with the steam. Through the use of ribs or other structures on the inner side of the cylinder sleeve it is possible to increase its inner surface by a factor of 10 to 100. In other words, the surface of the rib, honeycomb or lattice structure is ten to one hundred times greater than the inner surface of the outer sleeve layer.

In the interest of good heat conductance, copper or aluminium is used to manufacture at least the ribs or the ribs as well as the inside of the cylinder sleeve. However, steel or high-grade steel or some other metal or metal alloy can also be used to manufacture the structures applied to the inside of the cylinder sleeve provided a big enough factor for enlarging the surface is selected.

Preferably the material used to improve the thermal conductivity is the same as that of the cylinder sleeve connected to the structures in order to ensure that no stresses arise due to different thermal expansions.

It is an advantage to use a cylinder in which the outer sleeve layer is made of a material with a high thermal conductivity, i.e. with a high coefficient of thermal conductivity.

Preferably the outer layer is comprised of boiler steel. Steels with an austenitic microstructure are less suited.

The material from which the inner sleeve layer is made does not have to satisfy any

special requirements with regard to thermal conductivity; nevertheless it is an advantage for the inner sleeve layer to have a high modulus of elasticity and at least the strength of an average structural steel.

The advantages of the invention lie in the low mechanical load which exists because the steam is distributed only in ducts. A high thermal flow density is possible as the result of a reduced temperature gradient toward the surface. The heated cylinder is suitable for high compressive loads from outside and for high temperature stresses.

When the inventive cylinder is used with the same surface temperature as conventional drying cylinders, then a steam with a lower saturated steam pressure can be used. When the steam is used in a combined heat and power generating system, it can expand to a lower pressure in the turbine and thus produce more electric power.

It is an advantage for the cylinder to be connected by way of pipes between the inner and the outer sleeve layer via rotary bushings to a fixed steam supply or an exhaust steam and condensed water tank.

Given that the inner sleeve layer performs the load-bearing function and has a rigid core, it absorbs the loads acting on the outer sleeve layer.

In an embodiment of the invention provision is made for the inner and the outer sleeve layer to be connected by way of pins, screws, rivets and the like.

Alternatively or in addition to the embodiments of the cylinder described above, on which ribs or bars are used between the inner and the outer sleeve wall, provision is made in one embodiment of the invention for platelets to be fitted between the inner and the outer sleeve layer.

The platelets are arranged preferably parallel with each other, in particular in axial direction or also in circumferential direction of the cylinder, alternatively also crosswise, helically or in a honeycomb or lattice structure. In the case of a helical

structure, a few platelets form a screw-shaped helix around the longitudinal axis of the cylinder. With all structures, steps are taken to ensure that the steam is directed from an inlet end of the cylinder along the inside of its outer sleeve wall and out of the cylinder again, whereby the steam transfers a substantial part of its heat content to the outer sleeve wall.

The platelets have either a flat or a profiled surface. It is also an advantage for the platelets to become wider as they approach the outer sleeve shell.

In an embodiment of the invention provision is made for the surface of the structure on the inside of the outer sleeve layer at the circumferential end to become smaller near the end face. This is achieved either by a smaller height of the platelets, the honeycombs or lattice, or by larger spaces between the platelets or the walls of the honeycombs or the lattice in the edge region than in the middle of the outer sleeve layer. Making the surface of the heat-transfer structure smaller prevents the end-face edges of the sleeve layer from overheating.

The invention also relates to a heated cylinder for heating a paper web, cardboard web, tissue web and some other fiber web in a machine for producing and/or refining the fiber web which has only one outer cylinder sleeve.

The latter is invested with high stability according to the invention in that it is supported by struts inside the cylinder. The struts can be, for example, bars extending in radial direction; however, provision can be made similarly for supporting walls which dissect the longitudinal axis. The struts or walls lend the cylinder such stability that the sleeve wall needs to have only a small thickness. It is comprised of an efficiently heat-conducting material that transfers the heat, which was introduced into the inside of the cylinder by the fluid, to the fiber web being conveyed over its outer sleeve wall. This results in a higher energy yield than compared with the state of the art and a reduction of operating costs.

The invention is explained in more detail below using a single exemplary embodiment. In the appended drawing:

Fig. 1 is a cross section through a first cylinder,

Fig. 2 is a longitudinal section through the cylinder according to Fig. 1,

Fig. 3 is a perspective partial view of a second cylinder,

Fig. 4 is a greatly enlarged detail from the sleeve of the second cylinder in a sectional view along a line IV – IV in Fig. 3,

Fig. 5 is a detail from a sectional view of a third cylinder and

Fig. 6 is a cross section through another cylinder.

A cylinder 1 used as a heated cylinder (Fig. 1) comprises a core with a central axis 2 and an inner shell 5 which is connected to it via the end walls 3, 4 (Fig. 2). In addition, struts (not illustrated here) extending in radial direction between the central axis 2 and the inner shell 5 may be present to increase the stability of the cylinder 1.

The inner shell 5 has a much greater thickness than an outer sleeve layer 6. The inner sleeve layer or inner shell 5 is separated from and firmly connected to the outer sleeve layer 5 by means of bars 7. The regions between the bars 7 form ducts which extend parallel to the longitudinal axis of the cylinders 1 and together represent the steam space. Also, ribs 8 are fastened to the inner side of the sleeve layer 6 and enlarge the surface of the sleeve layer 6.

The cylinder 1 has in at least one of its bearing journals 9, 10 an outer ring-shaped pipe 11 and an inner pipe 12. Instead of the single outer pipe 11 it is also possible for there to be several outer pipes. Hot steam flows via the outer pipe 11 into the cylinder 1 and is routed first along the end wall 3 and then between the outer sleeve-side wall of the inner shell 5 and the inner wall of the outer sleeve layer 6. On the way, heat is transferred from the steam via the sleeve layer 6 to the fiber web which runs along between said sleeve layer and along the hood blower. The steam is cooled as the result and condenses in part to form water. The cooled steam and the condensate from the steam are directed on between the end wall 4 of the inner shell 5 and then through a central pipe 13 in the axis 2. The pipe 13 leads into the pipe 12 in the bearing journal 9.

Via rotary bushings (not illustrated here) the pipes 11, 12 are connected to a fixed steam supply or an exhaust steam and condensed water tank. Alternatively, instead

of the two pipes 11, 12 being routed through the same rotary journal 9 it is also possible for one of the two pipes 11, 12 to be directed through another bearing journal 10.

In another embodiment (Fig. 3) a cylinder 14 is constructed similarly with a double shell. In this case an inner shell 15 mainly performs the load-bearing function and serves as a rigid core that also absorbs, among other things, the loads of an outer thin sleeve layer 16.

The connection between the inner shell 15 and the sleeve layer 16 is made preferably by means of pins 17, which are either hollow-walled or are comprised of solid material. Said pins can have any cross sectional shape and be round, rectangular or hexagonal for example. The cross sectional shape can also change over the pin length. The pins 17 are pushed through openings in the sleeve layer 16 or in the inner shell 15 and are connected to the sleeve layer 16 and/or the inner shall 15 preferably by welding, in particular friction welding, or by gluing, screwing, soldering, clamping or some other techniques.

The pins 17 can also be constructed in two or more parts. Various methods such as screwing, gluing, clamping and welding or plastically deforming methods such as riveting are suitable for connecting the parts of the pins 17 to each other.

For example, the pins 17 can be screwed into the inner shell 15 in specially prepared drilled holes, punched holes or torch-cut holes with screw threads and be joined to the inner side of the sleeve layer 16 by friction welding or gluing. If the pins 17 are comprised of two parts, the first part for example can be attached to the inner side of the sleeve layer by friction welding while the second part of the pin is press-fitted to the inner shell 15.

Alternatively, a cylinder 18 (Fig. 5) constructed essentially like the cylinder 1 is equipped with one inner wall 19 and one outer wall 20. Platelets 21 are fitted between the two walls 19, 20. The platelets 21 extend either parallel to the longitudinal axis of the cylinder 18 or are helical. The hollow spaces between the platelets 21 are supplied with steam, as shown in Fig. 2 by the example of cylinder 1, in order to heat

the outer wall 19 which is very much thinner compared to the inner wall 20. Either all the platelets 21 are equally thick and all used to carry the outer wall 20, or provision is made between the platelets 21 for additionally reinforced platelets 22 which have mainly a load-bearing function while the platelets 21 perform mainly the heat transfer function. Like the cylinder 1 or the cylinder 14, the cylinder 18 is comprised of steel, in particular stainless steel.

The platelets 21, 22 either have the same cross section over their entire length or they become wider in the direction of the outer wall 20, as shown in Fig. 5. An outer structure can be applied in addition on to the platelets 21, 22 in order to enlarge once again the surface for the heat transfer between the steam and the outer wall 20.

In another embodiment of the invention (Fig. 6) provision is made for a cylinder 23 with just one outer wall 24 which is supported by struts 25, 26, 27 in the inside of the cylinder 18. The struts 25, 26, 27 are constructed either as bars or as continuous walls in longitudinal direction of the cylinder 23. Like the pins 17 they are connected to the outer wall 24 by screwed connections, welding, soldering, clamping or plastic deformation. The struts 25, 26, 27 can also be connected to each other.